will arise each year from the need to replace experienced machinists and programmers who transfer to other occupations or retire. The number of openings for machinists is expected to be greater than the number of openings for CNC programmers, primarily because the machinist occupation is larger.

Employment of machinists and CNC programmers is expected to grow more slowly than the average for all occupations through 2008. In spite of a robust economy, rising productivity among machinists and CNC programmers will limit their employment growth. Productivity gains are resulting from the expanded use of computer-controlled machine tools and new technologies, such as high-speed machining, which reduce the time required for machining operations. This allows fewer machinists to accomplish the same amount of work previously performed by more workers. Technology is not expected to affect the employment of machinists as significantly as most other production occupations, however, because many of the unique operations performed by machinists cannot be efficiently automated. In addition, firms are likely to retain their most skilled workers to operate expensive new machinery.

Despite increased use of CNC machine tools on shop floors, CNC programmers are also projected to grow more slowly than the average for all occupations through 2008. As advanced machine tool technology allows some programming and minor adjustments to be performed on the shop floor by machinists, tool and die makers, and machine operators, fewer CNC programmers will be needed. In addition, the demand for CNC programmers will be negatively affected by the increasing use of software that automatically translates part and product designs into CNC machine tool instructions.

Employment levels in these occupations are influenced by economic cycles—as the demand for machined goods falls, machinists and CNC programmers involved in production may be laid off or forced to work fewer hours. Employment of machinists involved in plant maintenance, however, is often more stable, because proper maintenance and repair of costly equipment remain vital concerns, even when production levels fall.

Earnings

Median annual earnings of machinists were $28,860 in 1998. The middle 50 percent earned between $22,670 and $36,100. The lowest 10 percent had earnings of less than $17,800, while the top 10 percent earned over $42,480. Median annual earnings in the manufacturing industries employing the largest number of machinists in 1997 were:

Aircraft and parts	$32,200
Metalworking machinery	28,300
Industrial machinery, not elsewhere classified	26,500

Median annual earnings of CNC programmers were about $40,490 in 1998. The middle 50 percent earned between $33,230 and $49,620. The lowest 10 percent had earnings of less than $27,170, whereas the top 10 percent earned over $72,290.

Related Occupations

Occupations most closely related to that of machinist and CNC programmer are other machining occupations. These include tool and die maker, metalworking and plastics-working machine operator, tool planner, and instrument maker. Workers in other occupations that require precision and skill in working with metal include blacksmiths, gunsmiths, locksmiths, metal patternmakers, and welders.

CNC programmers apply their knowledge of machining operations, metals, blueprints, and machine programming to write programs that run machine tools. Computer programmers also write detailed programs to meet precise specifications.

Sources of Additional Information

For general information about this occupation, contact:

☛ The Precision Machined Products Association, 6700 West Snowville Rd., Brecksville, OH 44141. Internet: **http://www.pmpa.org**

☛ The National Tooling and Machining Association, 9300 Livingston Rd., Fort Washington, MD 20744. Internet: **http://www.ntma.org**

Metalworking and Plastics-Working Machine Operators

(O*NET 89132, 91102, 91105, 91108, 91111, 91114A, 91114B, 91117, 91302, 91305, 91308, 91311, 91314, 91317, 91321, 91502, 91505, 91508, 91714, 91902, 91905, 91908, 91911, 91917, 91921, 91923, 91926, 91928, 91932, and 91938)

Significant Points

- A few weeks of on-the-job training is sufficient for most workers to learn basic machine operations, but several years are required to become a skilled operator.
- Projected employment change varies by type of job. Employment of most manual machine tool operators is expected to decline, while that of multiple and computer-controlled machine tool operators will grow.

Nature of the Work

Consider the parts of a toaster, such as the metal or plastic housing or the lever that lowers the toast. These parts, and many other metal and plastic products, are produced by metalworking and plastics-working machine operators. In fact, machine tool operators in the metalworking and plastics industries play a major part in producing most of the consumer products on which we rely daily.

In general, these workers can be separated into two groups—those who set up machines for operation and those who tend the machines during production. Set-up workers prepare the machines prior to production and may adjust the machinery during operation. Operators and tenders, on the other hand, primarily monitor the machinery during operation, sometimes loading or unloading the machine or making minor adjustments to the controls. Many workers set up and operate equipment. Because the set-up process requires an understanding of the entire production process, setters usually have more training and are more highly skilled than those who simply operate or tend machinery. As new automation simplifies the setup process, however, less skilled workers are also increasingly able to set up machines for operation.

Setters, operators, tenders, and set-up operators are usually identified by the type of machine with which they work. Some examples of specific titles are screw machine operator, plastics-molding machine set-up operator, punch press operator, and lathe tender. Job duties usually vary based on the size of the firm and on the type of machine being operated. Although some workers specialize in one or two types of machinery, many are trained to set up or operate a variety of machines.

Metalworking machine setters and operators set up and tend machines that cut and form all types of metal parts. Traditionally, set-up workers plan and set up the sequence of operations according to blueprints, layouts, or other instructions. They adjust speed, feed, and other controls, choose the proper coolants and lubricants, and select the instruments or tools for each operation. Using micrometers, gauges, and other precision measuring instruments, they may also compare the completed work with the tolerance limits stated in the specifications.

Although there are many different types of metalworking machine tools that require specific knowledge and skills, most operators perform similar tasks. Whether tending grinding machines that remove excess material from the surface of machined products or presses that extrude metal through a die to form wire, operators usually perform simple, repetitive operations that can be learned quickly. Typically, these workers place metal stock in a machine on which the operating specifications have already been set. They may watch one or more machines and make minor adjustments according to their instructions. Regardless of the type of machine they operate, machine tenders usually depend on skilled set-up workers for major adjustments when the machines are not functioning properly.

Plastics-working machine operators set up and tend machines that transform plastic compounds—chemical-based products that can be

produced in powder, pellet, or syrup form—into a wide variety of consumer goods such as toys, tubing, and auto parts. These products are manufactured using various methods, of which injection molding is the most common. The injection molding machine heats a plastic compound and forces it into a mold. After the part has cooled and hardened, the mold opens and the part is released. Many common kitchen products are produced using this method.

To produce long parts such as pipes or window frames, an extruding machine is usually employed. These machines force a plastic compound through a die that contains an opening of the desired shape of the final product. Yet another type of plastics working technique is blow molding. Blow-molding machines force hot air into a mold which contains a plastic tube. As the air moves into the mold, the plastic tube is inflated to the shape of the mold and a plastic container is formed. The familiar 2-liter soft drink bottles are produced using this method.

Regardless of the process used, plastics-working machine operators check the materials feed, the temperature and pressure of the machine, and the rate at which the product hardens. Depending on the type of equipment in use, they may also load material into the machine, make minor adjustments, or unload and inspect the finished products. Plastics-working machine operators also remove clogged material from molds or dies. Because molds and dies are quite costly, operators must exercise care to avoid damaging them.

Metalworking machine operators increasingly use numerically controlled (NC) equipment. These machine tools have two major components—an electronic controller and a machine tool. Today, most NC machines are computer numerically controlled (CNC), which means that the controllers are computers. The controller directs the mechanisms of the machine tool through the positioning and machining described in the program or instructions for the job. A program could contain, for example, commands that cause the controller to move a drill bit to certain spots on a workpiece and drill a hole at each spot.

CNC machine tools are often used in computer-integrated manufacturing systems. In these systems, automated material handling equipment moves workpieces through a series of stations where machining processes are computer numerically controlled. In some cases, the workpiece is stationary and the tools change automatically. Although the machining is done automatically, CNC machine tools must be set up and used properly in order to obtain the maximum benefit from their use. These tasks are the responsibility of CNC machine-tool operators or, in some instances, machinists. (See the statement on machinists and numerical control machine tool programmers elsewhere in the *Handbook*.)

Like the duties of manual metal and plastics machine operators, the duties of numerical-control machine-tool operators vary. Working from given instructions, CNC operators load programs that are usually stored on disks into the controller. They also securely position the workpiece, attach the necessary tools, and check the coolants and lubricants. Many CNC machines are equipped with automatic tool changers, so operators may also load several tools in the proper sequence. This entire process may require a few minutes or several hours, depending on the size of the workpiece and the complexity of the job.

A new program often must be adjusted to obtain the desired results. If the tool moves to the wrong position or makes a cut that is too deep, the program must be changed so the job is done properly. A machinist or machine tool programmer usually performs this function, occasionally with the assistance of a computer automated design program that simulates the operation of machine tools. However, a new generation of machine tool technology, known as direct numerical control, allows operators to make changes to the program and enter new specifications using minicomputers on the shop floor.

Because CNC machine tools are very expensive, operators monitor machinery to prevent situations that could result in costly damage to the cutting tools or other parts. The extent to which the operator performs this function depends on the type of job as well as the type of equipment being used. Some CNC machine tools automatically monitor and adjust machining operations. When the job has been properly set up and the program has been checked, the operator may only need to monitor the machine as it operates. These operators often set up and monitor more than one machine. Other jobs require frequent loading and unloading, tool changing, or programming. Operators may check the finished part using micrometers, gauges, or other precision inspection equipment to ensure that it meets specifications. Increasingly, however, this function is being performed by NC machine tools that are able to inspect products as they are produced.

Operating computerized machine tools is increasingly common.

CNC machines are changing the nature of the work that machine setters and operators perform. Computer-controlled machines simplify setups by using formerly tested computer programs for new workpieces. If a workpiece is similar to one previously produced, small adjustments can be made to the old program instead of developing a new program from scratch. Also, a growing number of CNC machine tools are able to inspect products as they are manufactured. As a result of these developments, CNC machine tool operators tend to have less physical interaction with the machinery or materials than manual machine tool operators. They primarily act as "troubleshooters," monitoring machines on which the loading, forming, and unloading processes are often controlled by computers.

Working Conditions

Most metalworking and plastics-working machine operators work in areas that are clean, well lit, and well ventilated. Nevertheless, many operators require stamina because they are on their feet much of the day and may do moderately heavy lifting. Also, these workers operate powerful, high-speed machines that can be dangerous if strict safety rules are not observed. Most operators wear protective equipment, such as safety glasses and earplugs to protect against flying particles of metal or plastic and noise from the machines. Other required equipment varies by work setting and machine. For example, workers in the plastics industry who work near materials that emit dangerous fumes or dust must wear face masks or self-contained breathing apparatuses.

Most metal and plastics-working machine operators work a 40-hour week, but overtime is common during periods of increased production. Because many metalworking and plastics-working shops operate more than one shift daily, some operators work nights and weekends

Employment

Metalworking and plastics-working machine operators held about 1,509,000 jobs in 1998. Of these, 1,421,000 were manual machine operators, and 88,000 were NC machine operators. About 8 out of every 10 metalworking and plastics-working machine operators are found in five manufacturing industries—fabricated metal products, industrial machinery and equipment, miscellaneous plastic products, transportation equipment, and primary metals. The following tabulation shows

the distribution of employment of metalworking and plastics-working machine operators by detailed occupation.

Cutting and forming machine tool setters and operators	726,000
Molding machine setters and operators	229,000
Sheet metal workers and duct installers, non-construction	102,000
Combination machine tool setters and operators	107,000
Numerical control machine operators	88,000
Plating machine setters and operators	45,000
Metal fabricators, structural metal products, non-construction	36,000
Heat treating machine setters and operators	23,000
All other metal and plastics-working machine operators	148,000

Training, Other Qualifications, and Advancement

Metalworking and plastics-working machine operators learn their skills on the job. Trainees begin by observing and assisting experienced workers, sometimes in formal training programs. Under supervision they may supply material, start and stop the machine, or remove finished products from the machine. They then advance to more difficult tasks such as adjusting feed speeds, changing cutting tools, or inspecting a finished product for defects. Eventually they become responsible for their own machines.

The complexity of equipment largely determines the time required to become an operator. Most operators learn the basic machine operations and functions in a few weeks, but they may need several years to become skilled operators or to advance to the more highly skilled job of set-up operator.

Set-up operators normally need a thorough knowledge of the machinery and of the products being manufactured because they often plan the sequence of work, make the first production run, and determine which adjustments need to be made. Strong analytical abilities are particularly important to perform this job. Some companies have formal training programs for set-up operators that combine classroom instruction with on-the-job training.

CNC machine tool operators undergo similar training. Working under a supervisor or an experienced operator, trainees learn to set up and run one or more types of numerically controlled machine tools. They usually learn the basics of their jobs within a few months. However, the length of the training period varies with the number and complexity of the machine tools the operator will run and with the individual's ability. If the employer expects operators to write programs, trainees may attend programming courses offered by machine tool manufacturers or technical schools.

Although no special education is required for most operating jobs, employers prefer to hire applicants with good basic skills. Many require employees to have a high school education and to read, write, and speak English. This is especially true for NC machine operators, who may need constant retraining as the company introduces new equipment. Because machinery is becoming more complex and shop floor organization is changing, employers increasingly look for persons with good communication and interpersonal skills. Mechanical aptitude, manual dexterity, and experience working with machinery are also helpful. Those interested in becoming metalworking or plastics-working machine operators can improve their employment opportunities by completing high school courses in shop and blueprint reading and by gaining a working knowledge of the properties of metals and plastics. A solid math background including courses in algebra, geometry, trigonometry, and basic statistics is also useful.

Job opportunities and advancement can also be enhanced by becoming certified in a particular machining skill. The National Institute for Metalworking Skills has developed standards for metalworking machine operators. After taking a course approved by the organization and passing a written exam and performance requirement, a credential is issued that formally recognizes the person as competent in a specific machining operation. The Society of Plastics Industry, Inc., the national trade association representing plastics manufacturers, also certifies workers in the plastics industry. To achieve machine operator certification, two year's experience operating a plastics processing machine is recommended, and one must pass a computer-based exam.

Advancement for operators usually takes the form of higher pay, although there are some limited opportunities for operators to advance to new positions as well. For example, they can become multiple machine operators, set-up operators, or trainees for the more highly skilled positions of machinist or tool and die maker. Manual machine operators can move on to CNC equipment when it is introduced in their establishments. Some set-up workers and CNC operators may advance to supervisory positions. CNC operators who have substantial training in CNC programming may advance to the higher-paying job of numerical control machine tool programmer. (See the statements on machinists and numerical control machine tool programmers, and tool and die makers elsewhere in the *Handbook*.)

Job Outlook

Divergent employment trends are expected over the 1998-2008 period among the various metalworking and plastics-working machine operators. In general, employment of these workers will be affected by the rate of technological implementation, the demand for the goods they produce, the effects of trade, and the reorganization of production processes. These trends are expected to spur employment growth among NC machine operators, combination machine tool operators, plastics molding machine operators, and a number of miscellaneous operating positions. On the other hand, employment is projected to decline in some of the more traditional operator occupations, such as manual cutting and forming machine tool operators, and sheet metal workers. Despite differing rates of employment change, a large number of metalworking and plastics-working machine operator jobs will become available due to an expected surge in retirements as the first of the baby boomers become eligible for retirement in the next decade.

One of the most important factors influencing employment change in this occupation is the implementation of labor-saving machinery. In order to remain competitive by improving quality and lowering production costs, many firms are adopting new technologies, such as computer-controlled machine tools and robots. Computer-controlled equipment allows operators to simultaneously tend a greater number of machines and often makes setup easier, thereby reducing the amount of time set-up workers spend on each machine. Robots are being used to load and unload parts from machines. For these reasons, the lower-skilled positions of manual machine tool operators and tenders are more likely to be eliminated by these new technologies because the functions they perform are more easily automated. The spread of new automation will lead to rising employment, however, for NC machine tool operators.

The demand for metalworking and plastics-working machine operators largely mirrors the demand for the parts they produce. Recent growth in the domestic economy, for example, has led to rebounding employment in a number of machine tool operating occupations. In addition, the consumption of plastic products has grown as they have been substituted for metal goods in many consumer and manufacturing products in recent years. Although the rate of substitution may slow in the future, this process is likely to continue and should result in stronger demand for machine operators in plastics than in metalworking.

Both industries, however, face stiff foreign competition that is limiting the demand for domestically-produced parts. One way that larger U.S. producers have responded to this competition is by moving production operations to other countries where labor costs are lower. These moves are likely to continue and will further reduce employment opportunities for many metalworking and plastics-working machine tool operators in the United States.

Workers with a thorough background in machine operations, exposure to a variety of machines, and a good working knowledge of the properties of metals and plastics will be best able to adjust to this changing environment. In addition, new shop floor arrangements will reward workers with good basic mathematics and reading skills, good communication skills, and the ability and willingness to learn new tasks. As workers are called upon to adapt to new production methods and to operate more machines, the number of combination machine tool operators will continue to rise.

Earnings
Earnings for machine operators can vary based on a number of different factors. The most important are the size of the company, whether the shop is union or nonunion, the industry, and skill level and experience of the operator. Also, temporary employees, who are being hired in greater numbers, usually get paid less than company-employed workers. The median annual earnings in 1998 for a variety of metalworking and plastics-working operators were:

Lathe and turning machine setters and set-up operators	$28,250
Sheet metal workers and duct installers	28,030
Numerical control machine operators	27,110
Heat treating machine setters and operators	25,160
Metal molding machine setters and operators	24,870
Grinding machine operators	24,740
Machine tool cutting operators	24,510
Metal fabricators, structural metal products	24,070
Combination machine tool setters and operators	23,860
Punching machine setters and operators	23,270
Electrolytic plating machine setters and operators	21,210
Machine forming operators	20,170
Plastic molding machine setters and operators	18,580

Approximately one-third of these workers are union members, about double the rate for other workers in the economy. Metalworking industries have a higher rate of unionization than the plastics industry.

Related Occupations
Workers in occupations closely related to metalworking and plastics-working machine operators include machinists, tool and die makers, extruding and forming machine operators producing synthetic fibers, woodworking machine operators, and metal patternmakers. Numerical-control machine-tool operators may program CNC machines or alter existing programs, which are functions closely related to those performed by NC machine tool programmers.

Sources of Additional Information
For general information about the metalworking trades, contact:
☛ The National Tooling and Machining Association, 9300 Livingston Rd., Fort Washington, MD 20744. Internet: **http://www.ntma.org**
☛ The Precision Machined Products Association, 6700 West Snowville Rd., Brecksville, OH 44141. Internet: **http://www.pmpa.org**
☛ The Society of Plastics Industry, 1801 K St. NW, Suite 600K, Washington, DC 20006.
Internet: **http://www.socplas.org** and **http://www.certifyme.org**

Tool and Die Makers

(O*NET 89102)

Significant Points

- Tool and die makers learn their trade through 4 or 5 years of education and training in formal apprenticeships, postsecondary programs, or informal on-the-job training.
- Advancements in automation and increased imports of precision metal products will contribute to the projected decline in employment; nevertheless, jobseekers with the appropriate skills and background should enjoy excellent opportunities.

Nature of the Work
Tool and die makers are among the most highly skilled production workers in the economy. These workers produce tools, dies, and special guiding and holding devices that enable machines to manufacture a variety of products we use daily—from clothing and furniture to heavy equipment and parts for aircraft.

Toolmakers craft precision tools which are used to cut, shape, and form metal and other materials. They also produce jigs and fixtures (devices that hold metal while it is bored, stamped, or drilled) and gauges and other measuring devices. Diemakers construct metal forms (dies) that are used to shape metal in stamping and forging operations. They also make metal molds for diecasting and for molding plastics, ceramics, and composite materials. In addition to developing, designing and producing new tools and dies, these workers may also repair worn or damaged tools, dies, gauges, jigs, and fixtures.

To perform these functions, tool and die makers employ many types of machine tools and precision measuring instruments. They must also be familiar with the machining properties, such as hardness and heat tolerance, of a wide variety of common metals and alloys. As a result, tool and die makers usually must have a much broader knowledge of machining operations, mathematics, and blueprint reading than most other machining workers.

Working from blueprints or instructions, tool and die makers first must plan the sequence of operations necessary to manufacture the tool or die. Next, they measure and mark the pieces of metal that will be cut to form parts of the final product. At this point, tool and die makers cut, drill, or bore the part as required, checking to ensure that the final product meets specifications. Finally, these workers assemble the parts and perform finishing jobs such as filing, grinding, and polishing surfaces.

Modern technology is helping to change the ways that tool and die makers perform their jobs. For example, these workers increasingly use computer-aided design (CAD) to develop products and parts. Specifications entered into computer programs can be used to electronically develop drawings for the required tools and dies. The electronic drawings are then processed by a computer-aided manufacturing (CAM) program to calculate cutting tool paths and the sequence of operations. Once these instructions are developed, computer numerically controlled (CNC) machines usually are used to produce the die. Programs can also be electronically stored and adapted for future use, saving time and increasing worker productivity.

Working Conditions
Tool and die makers usually work in toolrooms. These areas are quieter than the production floor because there are fewer machines in use at one time. They are also generally clean and cool to accommodate the growing number of computer-operated machines. To minimize the exposure of workers to moving parts, machines have guards and shields. Tool and die makers must also follow safety rules and wear protective equipment, such as safety glasses to shield against bits of flying metal, earplugs to protect against noise, and gloves and masks to reduce exposure to hazardous lubricants and cleaners. These workers also

Tool and die makers must be mechanically inclined and able to solve problems independently.